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BARIUM CLOUD TEST IN PERU.(U)

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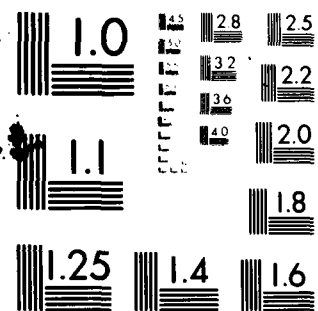
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BARIUM CLOUD TEST IN PERU

Allen L. Johnson
Roger L. Swanson

Information Transmission Branch
System Avionics Division

November 1981

Interim Report for Period March 1979 - April 1979

SELECTED
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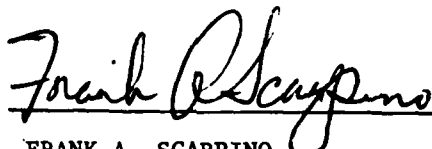
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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) In an effort to investigate the mechanism causing ionospheric irregularities to form in the equatorial region an experiment was designed by the Max Planck Institute involving the release of two barium clouds in the F region just after sunset. The electric field resulting from the two barium clouds was expected to trigger an ionospheric irregularity which would propagate up through the ionosphere as a depletion bubble. This report describes an attempt to observe the ionospheric irregularity as it passed through the line-of-sight between an aircraft and a communication satellite. | | |

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The aircraft was equipped with a UHF receiver which measured phase & amplitude of the downlink Satellite Signal. Due to the release of the barium 50 km below the planned altitude no significant ionospheric irregularities were formed. The aircraft measured minor amplitude variation (1dB) and no significant phase variations resulting from ionospheric irregularities triggered by the barium release.

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FOREWORD

The effort reported in this technical report was accomplished during the period 1 March through 30 April 1979 under Project 1227, "Terminal Segment Technology," and Work Unit 12270313, "SATCOM Flight Test," with T. A. Grizinski as Work Unit Manager. The test was supported by an international group described in the introduction of this report.

The accomplishment of this test was made possible by the cooperation and support of a large number of organizations and individuals, including:

| | | |
|-------------------|---------------------------|--------------|
| Dr. G. Haerendal | Max Planck Inst. | West Germany |
| Dr. A. Valenzuela | Argentine Space Comm. | Argentina |
| Ing A. Gieseke | Geological Inst. | Peru |
| Mr. J. Buchau | Air Force Geophysics Lab. | U. S. |
| Mr. J. Moore | " " " " " | U. S. |
| Dr. E. Weber | Air Force Geophysics Lab. | U. S. |
| Mr. R. Chin | 4950th Test Wing | U. S. |
| Dr. C. Prettie | Berkeley Research Assoc. | U. S. |
| Lt. R. N. Wright | 4950th Test Wing | U. S. |

An extensive test team of AFWAL/contractor engineers and 4950th TW flight/support crew cooperated to make the test and data reduction effort feasible.

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SECTION I

INTRODUCTION

The Avionics Laboratory has recently completed evaluation of a Dual Frequency (SHF/EHF) satellite communication terminal installed on a 4950th Test Wing C135 aircraft. In connection with that evaluation, a flight test was conducted through South America in March 1979 to evaluate the performance of the dual frequency antenna systems at high elevation angles and the performance of the dual frequency terminal under various doppler conditions (Reference 1). A second objective for the trip was to evaluate equatorial UHF ionospheric scintillation fading to determine the effect it had on satellite communication link availability. In conjunction with the UHF scintillation test the Avionics Laboratory participated in a barium cloud test while in Peru.

The barium cloud test designated CASTOR was designed by the Max Planck Institute, West Germany (Reference 2). The barium cloud was designed to trigger an equatorial ionospheric irregularity just prior to the time when natural irregularities might occur. The development of an artificial irregularity would help scientists better understand the mechanism which causes natural ionospheric irregularities. The experiment, designed by Dr Haerendal and Dr Valenzuela, called for the release of two barium clouds on the bottom side of the equatorial F region, just after sunset. It was believed that these barium clouds would cause an electric field to be set up, which could trigger an ionospheric bubble. The bubble was expected to rise rapidly through the ionosphere, creating the ionospheric disturbance. The barium clouds would be injected to the west of Lima, Peru and would then be expected to drift east with the neutral ionospheric winds across the Jicamarca backscatter radar site. The irregularity would be measured by the AFWAL and AFGL equipped aircraft, the Jacamarca radar site, and receivers set at several Peruvian ground sites. The rocket payload was developed by the Max Planck Institute. The rocket itself has the responsibility of the Argentine Space Commission (CNIE). The launch was made from Punta Lobos, Peru, a station of the Peruvian Space Commission (CONIDA).

SECTION II

DESCRIPTION OF TEST

Two Castor rocket launches were scheduled for the period 17 through 25 March 1979. Each rocket launch would carry two barium payloads. The first launch occurred at 2349Z on 21 March. However, the rocket failed to eject the barium payloads at the desired altitude. The second Castor rocket launch occurred at 2353Z on 22 March. The rocket followed the projectory shown in Figure 1 and ejected the two barium payloads at approximately a 250 kilometer altitude, slightly below the planned altitude. After injection, the barium ions diffused rapidly north and south along the magnetic field lines forming a football-shaped irregularity ion cloud (Figure 2). The clouds were then expected to drift eastwardly with the neutral ionospheric winds, crossing the Jicamarca magnetic meridian approximately 30 minutes after injection.

The AFGL test aircraft was equipped with a camera, ionospheric sounder, allsky photometer, and UHF receivers to measure the effects of the ionospheric irregularity. Immediately following the barium injection, AFGL aircraft flew an arc around the barium cloud, photographing the development of the barium ionospheric structure. Then the AFGL aircraft flew south to measure the 6300 Å airglow. It was expected that the barium ions would cause a "biteout" in the airglow structure along the magnetic meridian of the barium injection.

The Avionics Laboratory (AFWAL) aircraft was equipped with UHF satellite communication systems to measure the amplitude and phase effects of the ionospheric scintillation caused by the barium injection. The AFWAL aircraft was positioned such that its line-of-sight to the LES-9 satellite would initially cut through the area of the barium injection. The flight path was then programmed such that the ray between the aircraft and the LES-9 satellite would explore the area

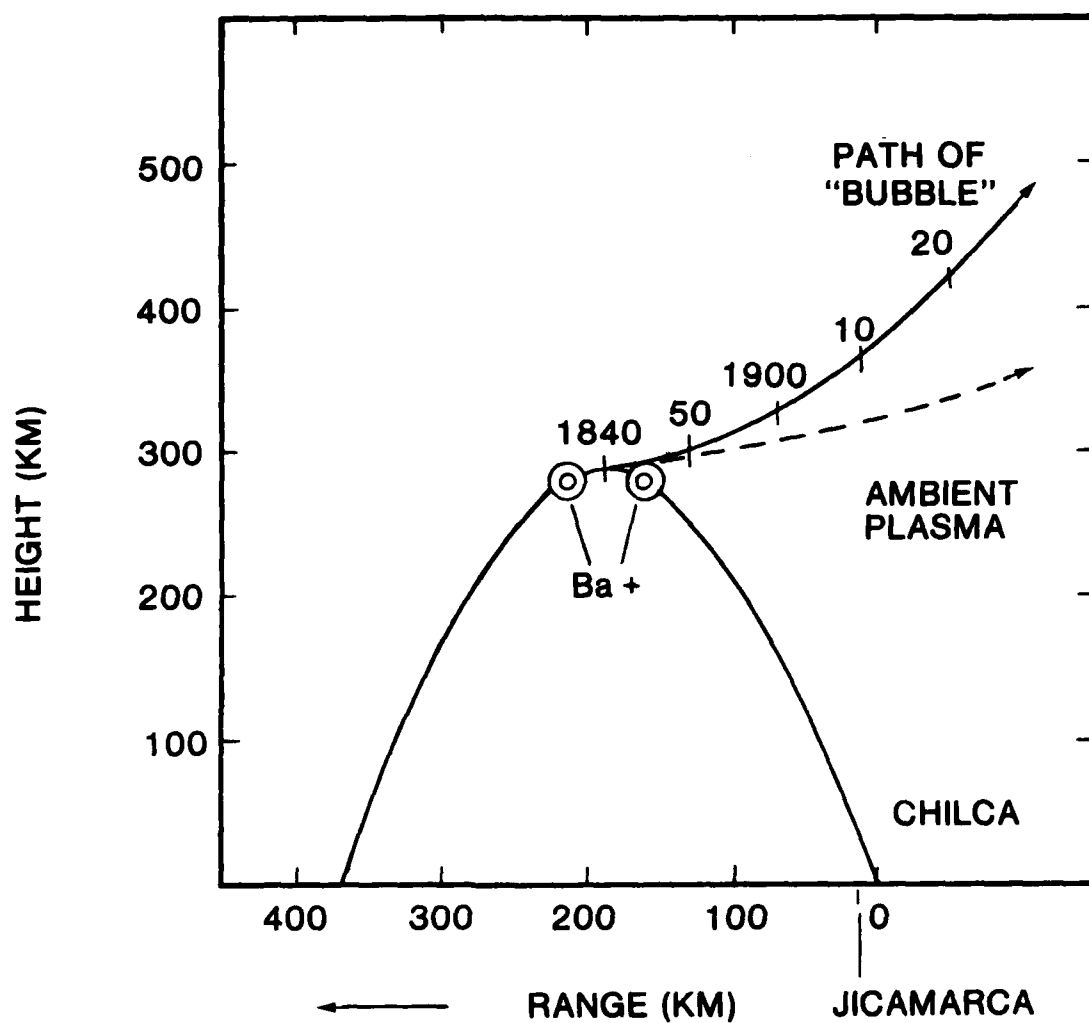


Figure 1. Planned Trajectory of Barium Rocket

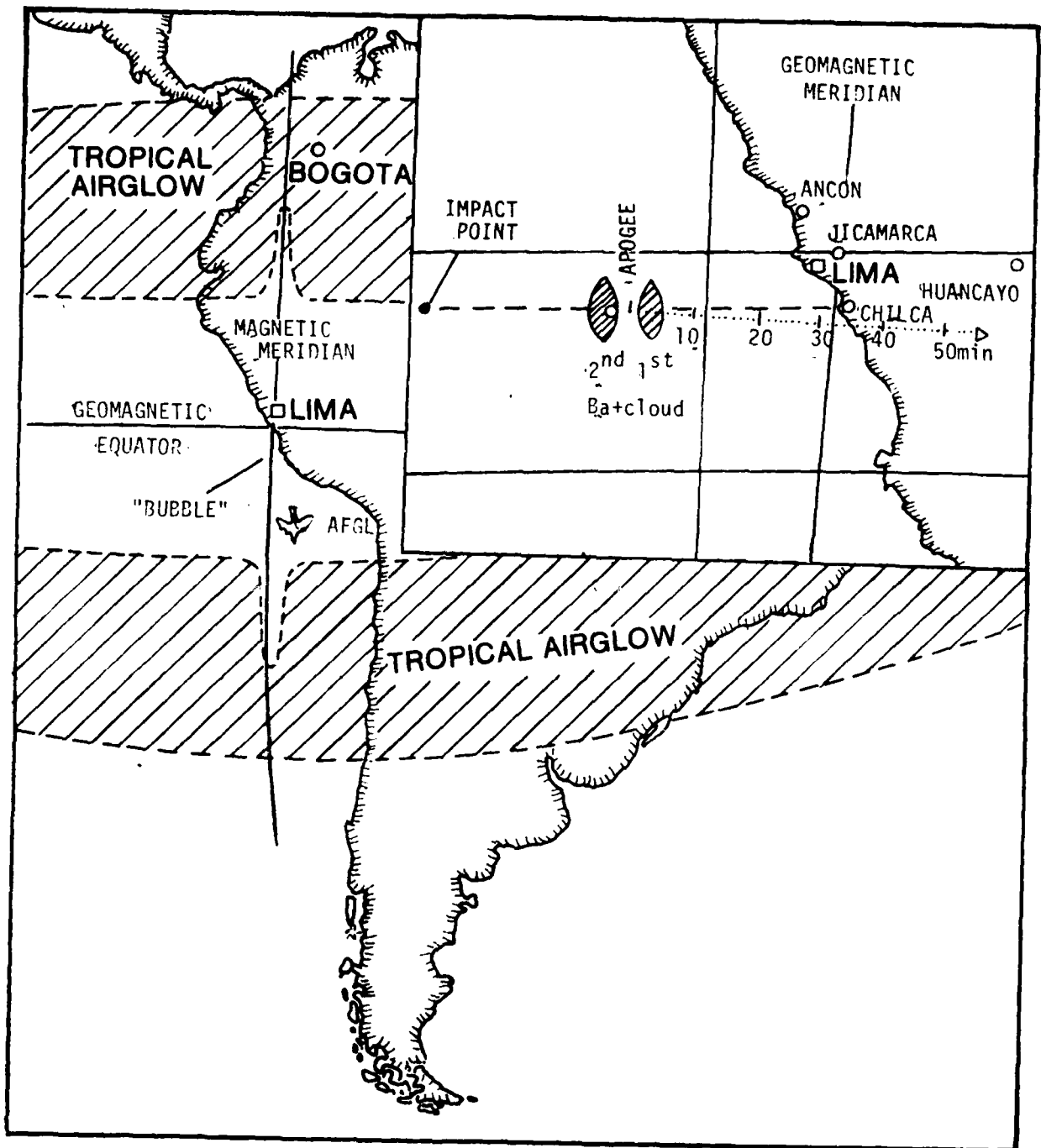


Figure 2. Planned Drift of Barium Cloud

immediately above the barium cloud to look for the expected developing irregularity as the bubble rose through the ionosphere. The AFWAL aircraft also photographed the barium release obtaining the results shown in Figures 3 through 5. Figure 3 depicts the release of the second barium payload and shows the expansion of the first barium cloud four minutes after injection. Figures 4 and 5 show the development of the barium clouds with time. Approximately 45 minutes after the initial barium injection, the sun set on the barium clouds and they were no longer visible.

Results of optical measurements of the barium cloud location are presented in Figures 6 and 7 (Reference 3).

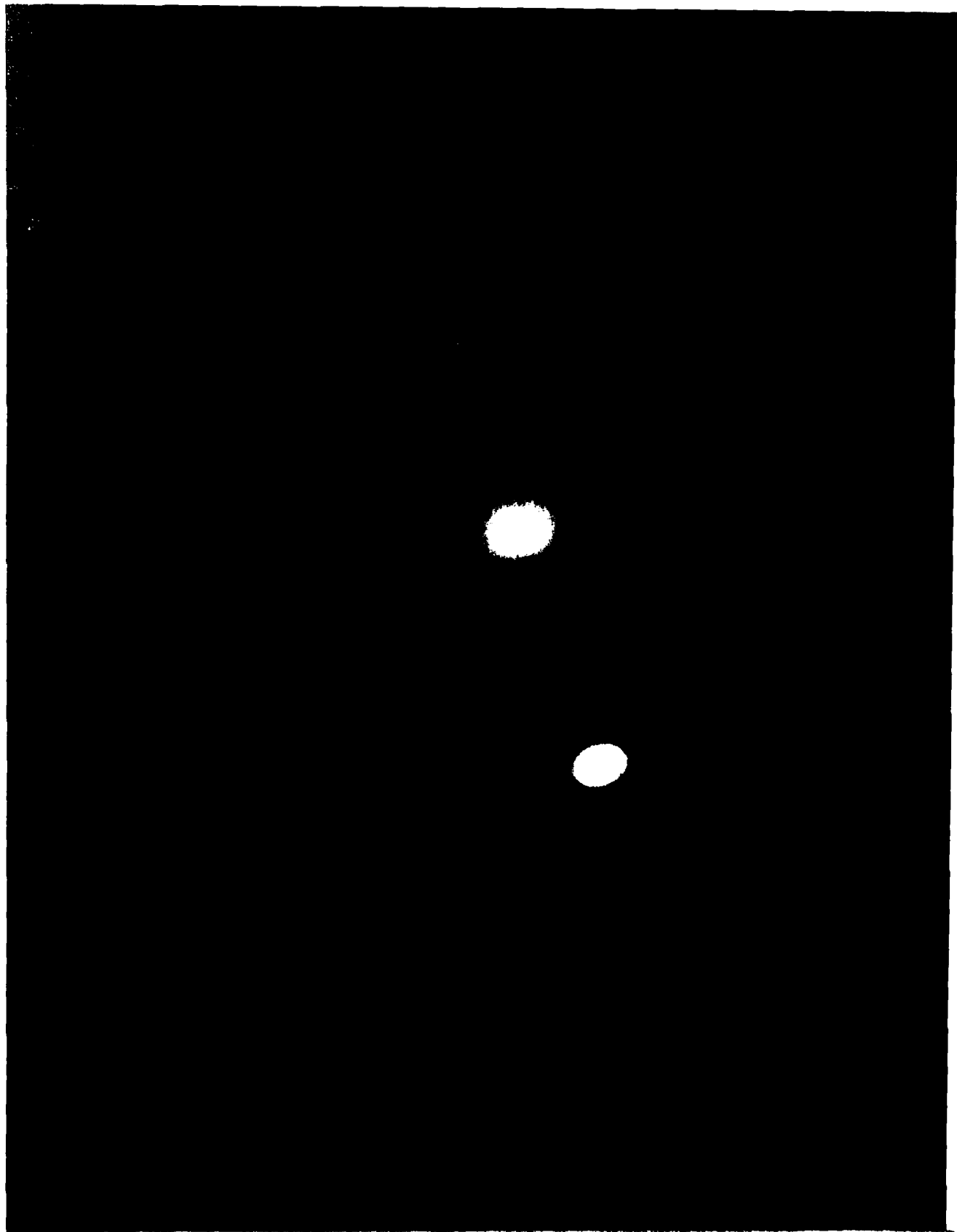
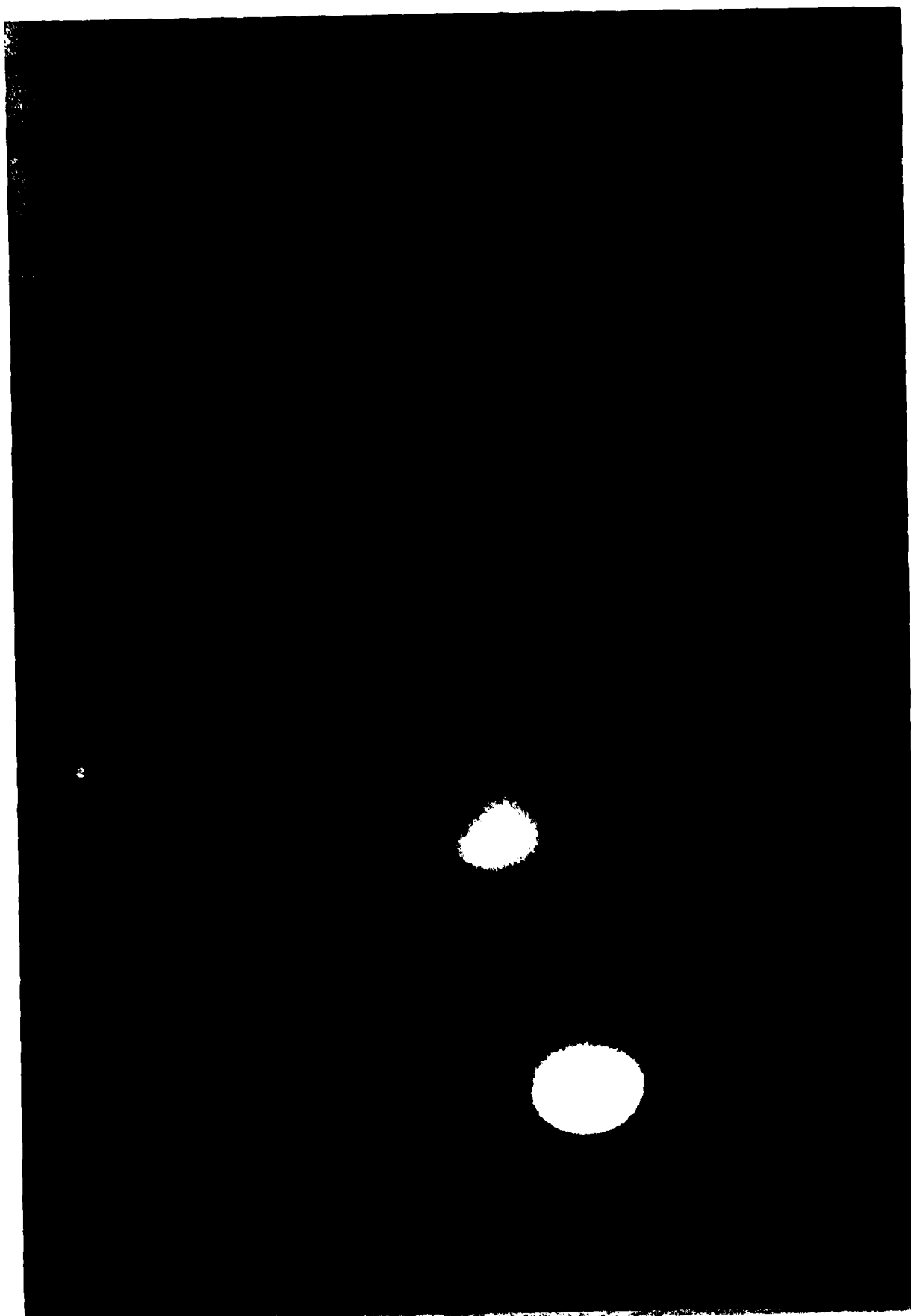


Figure 3. Release of Second Barium Cloud

Figure 4. Expansion of Barium Cloud



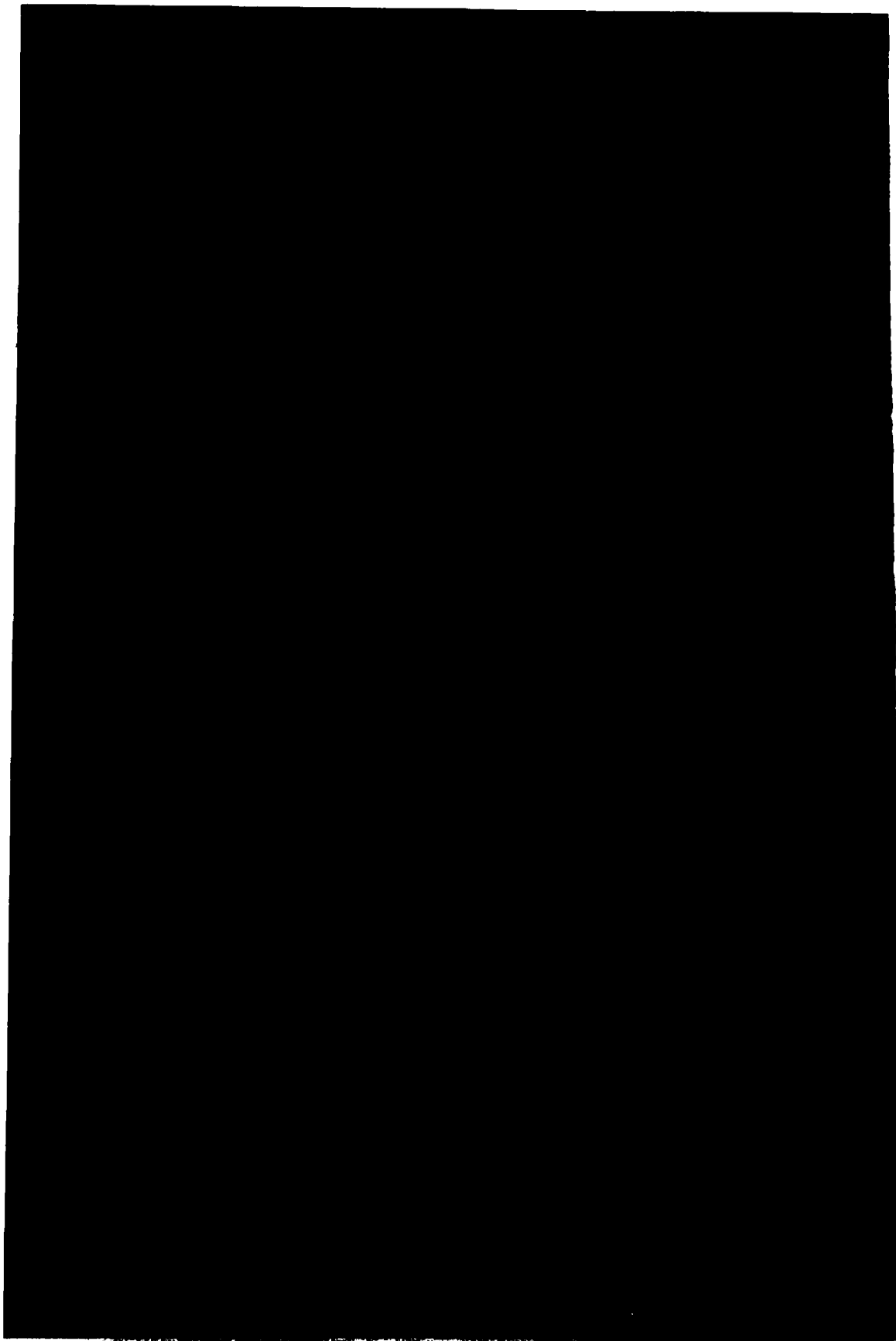


Figure 5. Fully Developed Barium Cloud

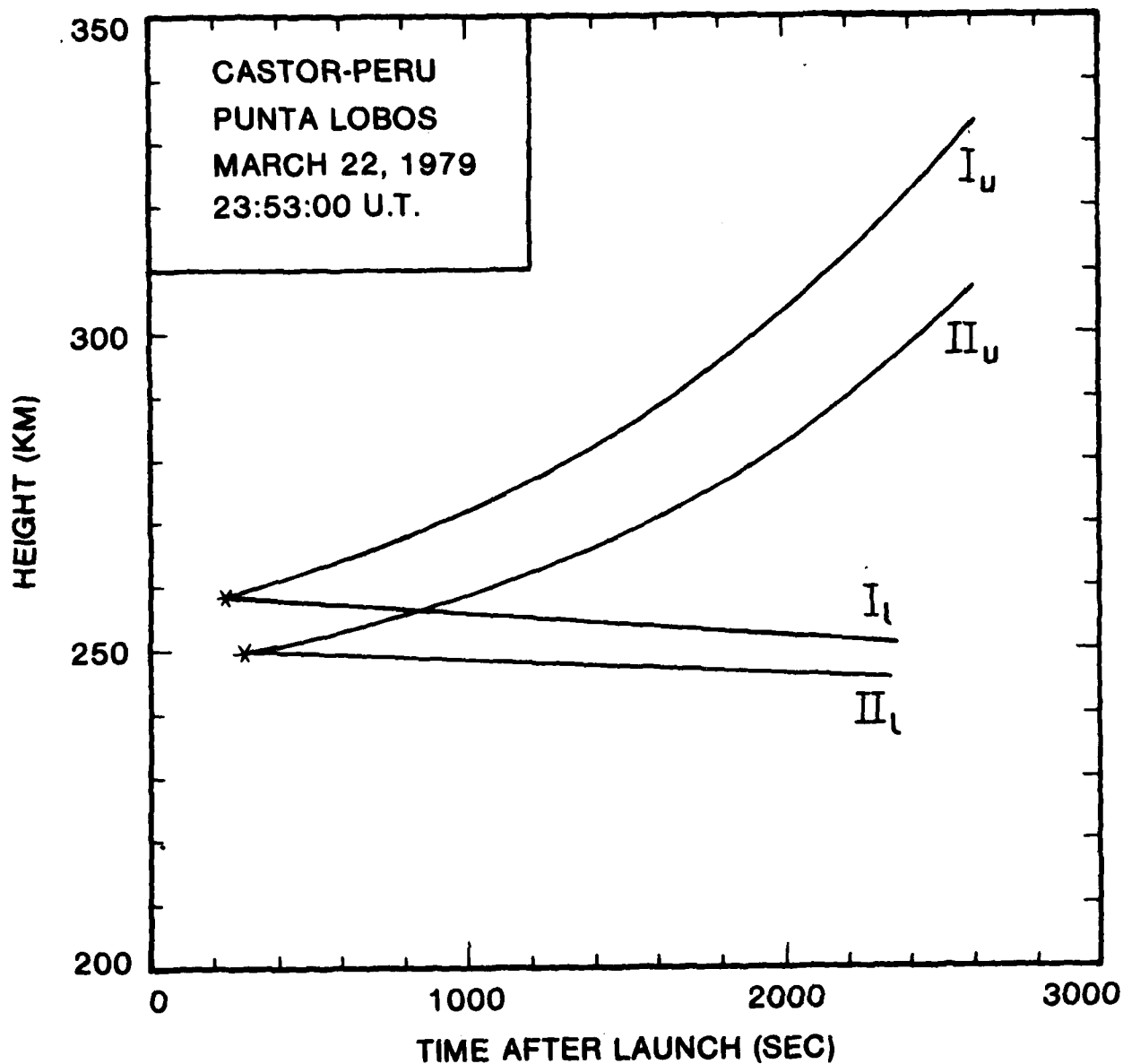


Figure 6. Height of Barium Cloud After Injection

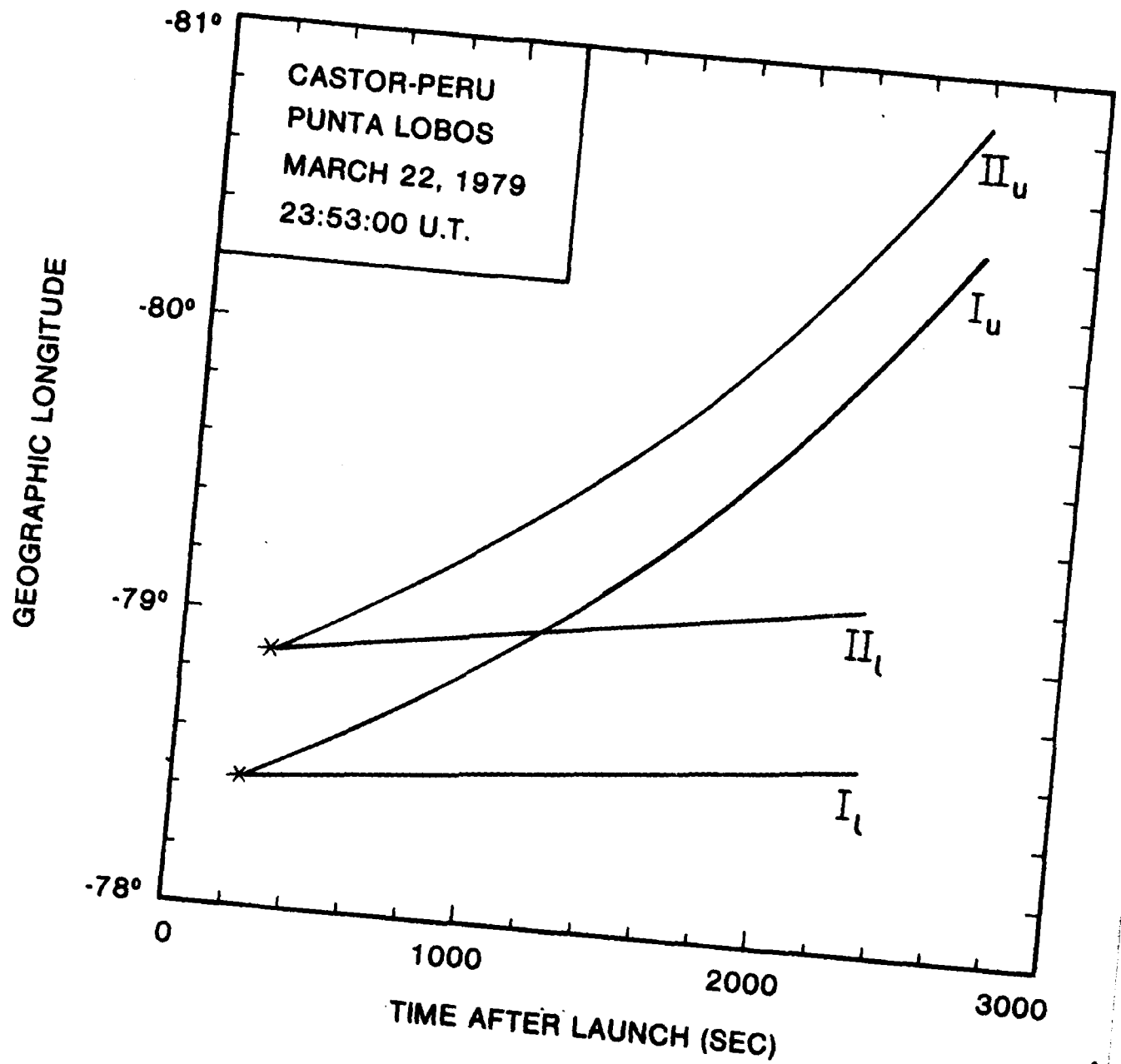


Figure 7. Drift of Barium Cloud After Injection

SECTION III

TEST RESULTS

The AFWAL aircraft measured the amplitude and phase of CW UHF signals from the LES-9 satellite. Amplitudes of the UHF signals from the LES-8 and FLTSAT satellites were also recorded. The aircraft flight track from the time just prior to launch, to an hour and a half after launch is shown in Figure 8. A plot of the points at which the line-of-sight from the aircraft to LES-9 satellite penetrated the 300 kilometer and 450 kilometer altitudes is also shown in Figure 8. The aircraft coordinates, elevation angle, and azimuth to the LES-8 and LES-9 satellites and to the barium cloud are tabulated in Table 1.

The barium release occurred about 50 km lower than planned. Instead of drifting east with the neutral winds the barium was caught in a wind shear. The bottom portion of the cloud remained more or less stationary at the injection point while the top drifted rapidly westward (Figure 7). The projection of the cloud on the aircraft line-of-sight is shown in Figure 8 for 37 minutes and 52 minutes after launch.

From Figure 8 it appears that the most likely time for the aircraft line-of-sight to have passed through the barium cloud is between 0030Z and 0057Z.

A detailed analysis of the data taken during that period shows a small amplitude disturbance occurring at 0038-0040Z (Figure 9) just prior to the turn at the western most portion of flight.

Analysis of the UHF Signal Phase during that period shows no significant phase variations during the time period under question (Figure 10), (Reference 4).

TABLE 1

AZ/EL TO THE SATELLITES & BARIUM CLOUD (22/23 MARCH 1979).

| TIME | AIRCRAFT 662 | | LES 9 | | LES 8 | | BARIUM CLOUD | |
|------|--------------|----------|-------|-----|-------|-----|---------------------|---------------------|
| | LAT | LONG | AZ | EL | AZ | EL | AZ | EL |
| 2350 | 14° 45'S | 77° 15'W | | | | | | |
| 2357 | 14° 42'S | 78° 00'W | 58° | 42° | 41° | 35° | 70° | 34°(1st) |
| 2358 | 14° 42'S | 78° 06'W | 58° | 42° | 41° | 35° | 65° | 31°(2nd) |
| 0005 | 14° 50'S | 77° 53'W | | | | | | |
| 0014 | 15° 26'S | 76° 48'W | | | | | | |
| 0016 | 15° 32'S | 76° 25'W | 225° | 41° | 207° | 34° | 210° | 26° |
| 0022 | 15° 15'S | 76° 41'W | 46° | 39° | 29° | 33° | 35° | 25° |
| 0030 | 14° 52'S | 77° 36'W | 46° | 39° | 30° | 31° | 30 ⁺ 20° | 30 ⁺ 20° |
| 0040 | 14° 23'S | 78° 43'W | 47° | 41° | 31° | 33° | | |
| 0047 | 14° 14'S | 78° 43'W | 228° | 43° | 211° | 35° | | |
| 0100 | 15° 13'S | 77° 16'W | 226° | 43° | 210° | 35° | | |
| 0112 | 15° 48'S | 75° 58'W | 226° | 42° | 209° | 34° | | |

22/23 MARCH 1979
AIRCRAFT C-135/662
LES 9 SATELLITE
NEAR LIMA PERU

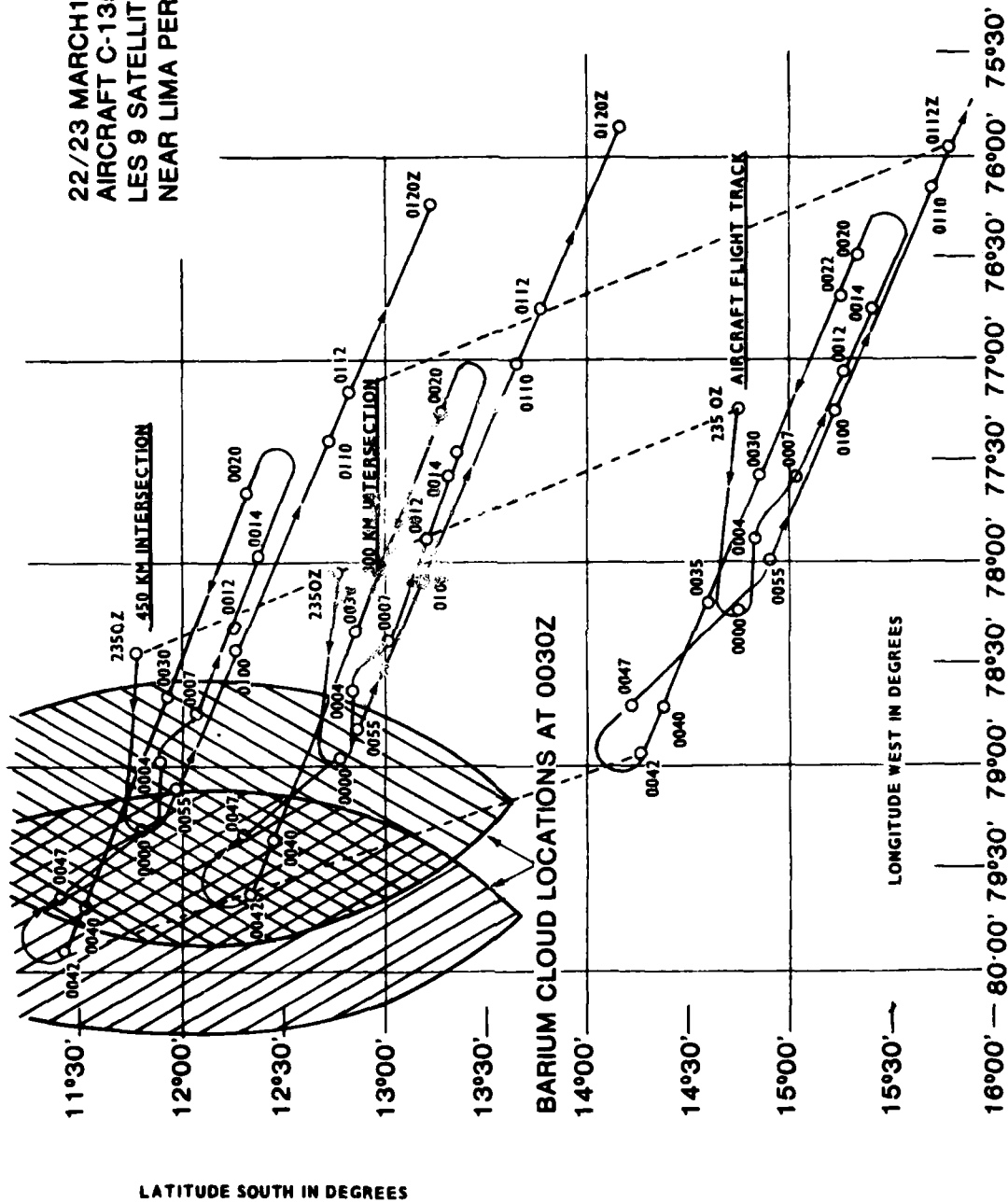


Figure 8. Aircraft Flight Track and Ionospheric Intersection

22/23 MARCH 1979
AIRCRAFT C-135/662
LES-9 UHF SATELLITE

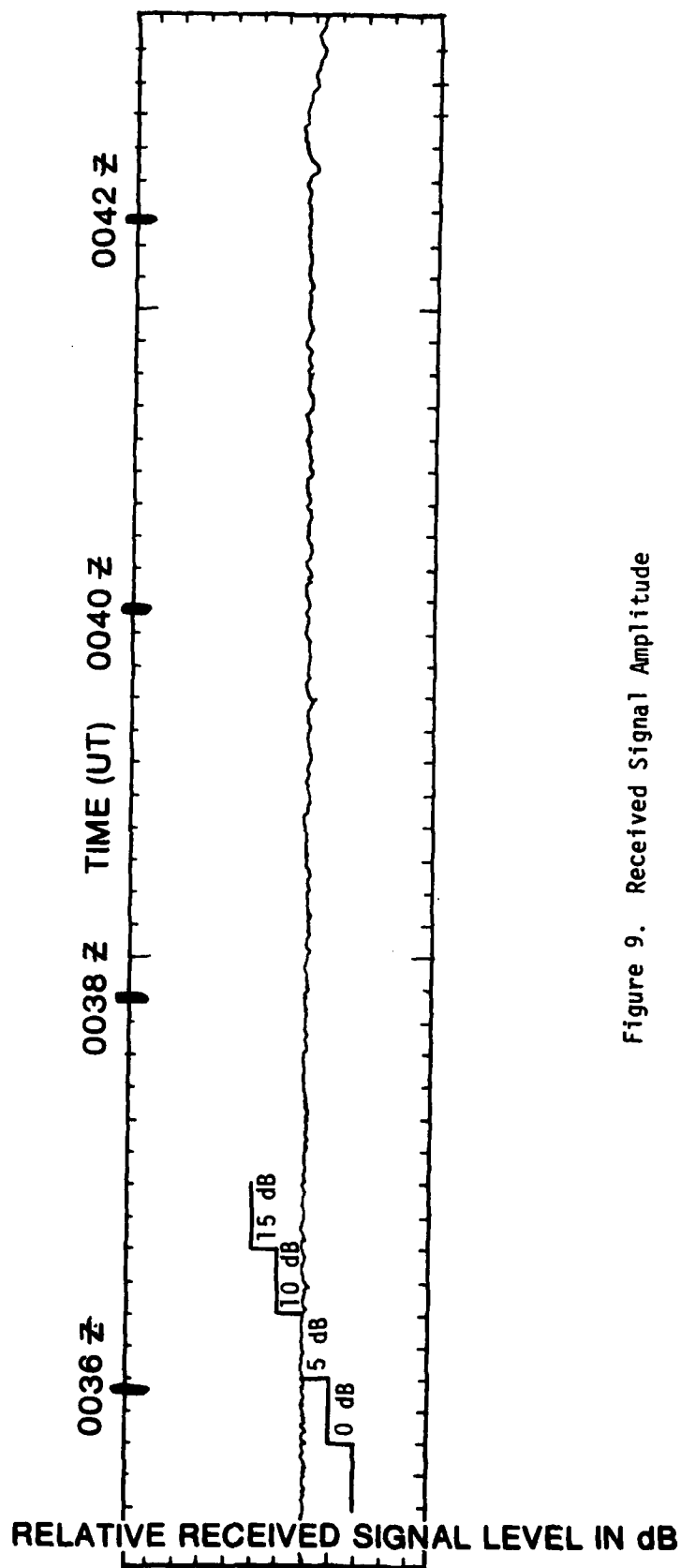
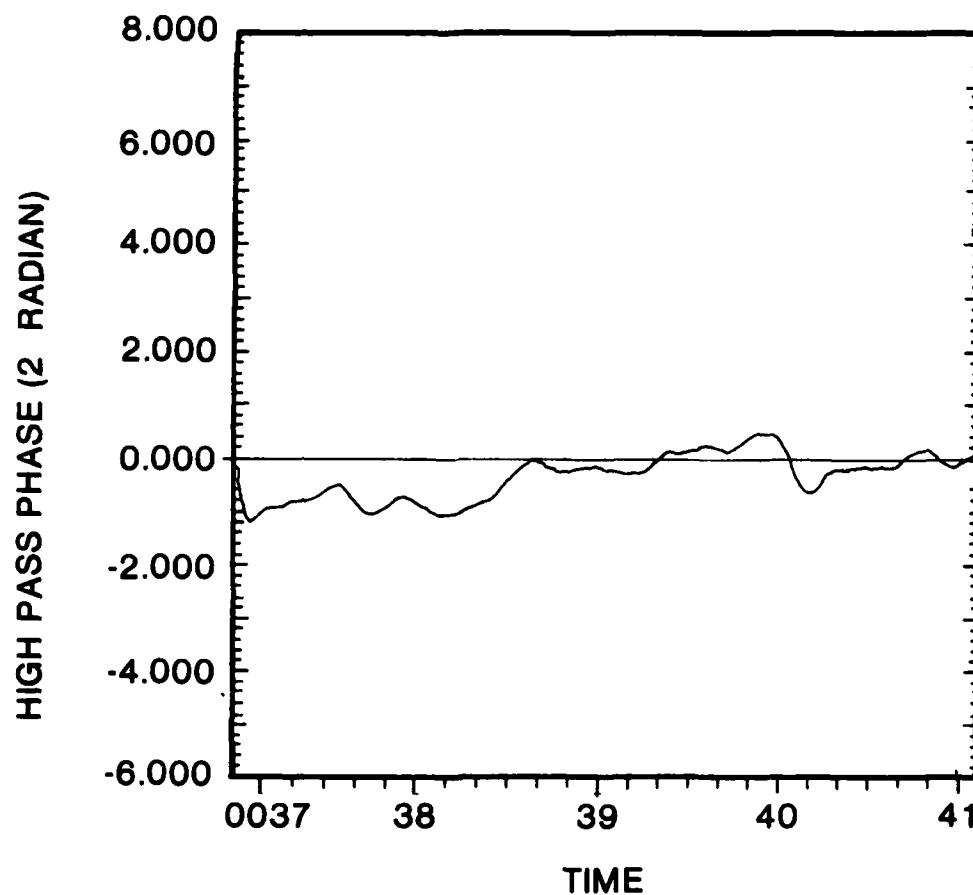


Figure 9. Received Signal Amplitude

22/23 MARCH 1979
AIRCRAFT C-135/662
LES-9 UHF SATELLITE



LES-9 FILE 1 PART 1

Figure 10. Received Signal Phase

SECTION IV
CONCLUSIONS

Extensive UHF signal phase and amplitude measurements were made of the LES-9 satellite-to-earth signal as it passed through the barium clouds generated by the Castor experiment. It appears that due to the failure of the rockets to reach their intended release altitude the barium cloud was in a valley under the F region rather than in the steep gradient (Reference 3). This hampered the formation of a bubble type irregularity. The aircraft did measure a minor amplitude variation caused by small scale irregularities about 45 minutes after launch. No measurable phase variations were detected by the aircraft measurements.

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